

REMARKS

In the final Office Action, claims 1, 2, 7-9, 20 and 21 were rejected under 35 U.S.C. §102(a) as being anticipated by Katsuma, Miyazawa and Vishnevsky '580. The Examiner pointed to Fig. 7 of Katsuma, Fig. 62 of Miyazawa and Fig. 4 of Vishnevsky and noted that each reference teaches a piezoelectric stator mounted to a substrate having a conductive pattern and a mounting to electrically and mechanically connect the piezoelectric element to the power supply.

Claims 4 and 6 were rejected under 35 U.S.C. §103(a) as being unpatentable over Miyazawa, Vishnevsky '580 and Katsuma. The Examiner stated that each reference discloses the claimed structure except that the support member is provided as a separate element (Vishnevsky 19, Miyazawa 52, 38, and Katsuma 4). The Examiner further stated that it is within the skill expected of the routineer to make parts integral or separable.

Applicants and applicants' counsel acknowledge with appreciation the allowance of claims 10-19 and 28-32 and the indication of allowable subject matter with respect to claims 3, 5 and 22-27. For the reasons stated below, however, applicants respectfully submit that independent claims 1 and 20 are patentably distinct from the prior art of record.

The present invention relates to an ultrasonic motor having improved vibration efficiency. As pointed out by applicants at pages 1-2 of the specification, a conventional ultrasonic motor utilizes an elastic member to resiliently bias a piezoelectric element against a moving member to efficiently transmit a drive power due to oscillation of the piezoelectric element to the movable member. The conventional ultrasonic motor relies upon the expansion-and-contraction and flexural vibration of the piezoelectric element to drive the movable member and uses signal lines to transmit drive signals from a circuit board to the piezoelectric element.

The conventional ultrasonic motor is typically installed on a circuit board by means of a support member which holds the piezoelectric element to the circuit board, and signal transmission extends between the circuit board and the piezoelectric element for applying a drive signal to the piezoelectric element.

As further noted by applicants, the use of the support member, the signal transmission wires and the elastic member results in a significant loss in expansion-and-contraction and flexural vibration of the piezoelectric element. Thus, the general structure of the conventional ultrasonic motor lends to inefficient transmission of drive force from the piezoelectric element to the moving member and impairs the electric-to-mechanical energy conversion.

The present invention provides an ultrasonic motor with a reduced loss in the drive force produced by a piezoelectric element so that the drive force is efficiently transmitted to a moving member, and facilitates a size reduction and improvement in reliability by eliminating unnecessary components from the motor.

In accordance with one aspect of the present invention recited by independent claims 1 and 20, the ultrasonic motor comprises a movable member disposed to undergo movement in response to a drive force, a substrate having a conductor pattern for conveying a drive signal from a drive circuit, a piezoelectric vibrator provided on the substrate for undergoing oscillating movement in response to the drive signal so as to contact the movable member and thereby generate the drive force for driving the movable member, and a support member provided on the substrate for mechanically supporting the piezoelectric vibrator on the substrate and transmitting the drive signal from the conductor pattern to electrodes of the piezoelectric vibrator.

By the structure recited in claims 1 and 20, the support member serves the dual function of supporting the piezoelectric element and transmitting the drive signal from the conductor pattern to the piezoelectric element. As a result, there is no need for conductor wires extending from

the substrate to connect the drive circuit and the piezoelectric vibrator, and vibration loss is reduced.

Each of the Examiner's rejections is based on the premise that the cited references either explicitly disclose or render obvious the use of a support member having a conductive path

However, an equally significant aspect of the invention recited by independent claims 1 and 20 is that the piezoelectric element of the ultrasonic motor undergoes oscillating movement in response to the drive signal so as to contact the movable member and thereby generate the drive force for driving the movable member. The cited references fail to disclose this subject matter of claims 1 and 20.

As noted above, the conventional piezoelectric ultrasonic motor utilizes an elastic member for biasing the piezoelectric element in contact with the movable member and conductive wires for conveying a drive signal produced by a drive circuit to the piezoelectric element. The use of separate components to accomplish these tasks leads to an increase in the size of the ultrasonic motor and a loss in the expansion-and-contraction and flexural vibration of the piezoelectric element.

The present invention recited in claims 1 and 20 overcomes these problems by providing an ultrasonic motor in

which a piezoelectric element directly contacts a movable member in response to oscillation thereof and drives the movable member. The claimed invention also eliminates the need for separate conductor wires and a support member by providing a support member capable of serving as a conductive path. According to the present invention, the support member not only supports the piezoelectric element on a substrate, but also has the ability to transmit a drive signal to the piezoelectric element so that no conductor wires are needed.

Thus, in accordance with the present invention, a piezoelectric element comes into and out of direct contact with a movable member to cause the movable member to undergo movement. The cited references do not disclose or suggest this aspect of the invention.

The support member is preferably formed of a resilient material or has a flexible portion so that it resiliently urges the piezoelectric element against the movable member, thereby eliminating the need for a separate elastic member to bias the piezoelectric element and movable member. Accordingly, the present invention makes it possible to substantially reduce the size of the ultrasonic motor and reduces the loss associated with the use of multiple components as described above.

An embodiment of the inventive ultrasonic motor is shown in Fig. 1 of the application drawings. The motor includes a rectangular piezoelectric element 10 that receives a drive signal X to undergo elliptical vibration. Support members 11, 11 hold the piezoelectric element 10 on a substrate 7 and deliver signals through signal lines 7a, 7b printed on the substrate 7. A symmetry member 12 has a movable member 12a in contact with an end of the piezoelectric element 10. A drive circuit IC 6 is provided on the substrate 7 to supply the drive signal X to the piezoelectric element 10 through the signal lines 7a, 7b and conductors formed on the support members 11, 11.

The ultrasonic motor 1 operates by elliptic vibration of the end face of the piezoelectric element 10 produced in response to the drive signal X to come into and out of direct contact with the movable member 12a and to thus cause the movable member 12a to undergo movement in a direction parallel to the end face.

The support members 11, 11 may be formed of a resin material in an L-shaped form and each may be provided with three signal lines formed on a surface thereof. The support members 11, 11 have six signal lines, and six corresponding electrodes are formed on side faces of the piezoelectric element 10.

The support members 11, 11 have one side 11a fixed to the signal line 7a of the substrate 7, such as by solder, and the other side 11b fixed to a side of the piezoelectric element 10 by means of a conductive adhesive or the like. The support members 11, 11 thus hold the piezoelectric element 10 to the substrate 7 and connect between electrodes of the piezoelectric element 7 and the signal lines 7a or 7b. The support members 11, 11 thus serve to support the piezoelectric element and further serve as signal transmission means for transmitting the drive signal X to the piezoelectric element 10. As a result, the number of components of the ultrasonic motor is reduced, and the size and loss factor of the motor are also reduced.

The piezoelectric element 10 has a first piezoelectric vibrator 14 serving as a flex vibration source and a second piezoelectric vibrator 15 laminated thereon and serving as an expansion-and-contraction vibration source. The piezoelectric element 10 has electrodes 13a-13f respectively connected to the six electrodes on the substrate 7 and the support members 11, 11 to cause the respective vibrators 14, 15 to undergo vibration. This combination of vibration sources produces the elliptical motion of the piezoelectric element 10.

The cited references fail to disclose the subject matter recited by amended independent claims 1 and 20. Claims 1 and 20 each recite a piezoelectric vibrator provided on a substrate for undergoing oscillating movement in response to a drive signal so as to contact the movable member and thereby generate the drive force for driving the movable member. The substrate has a conductor pattern for conveying a drive signal from a drive circuit, and the support member mechanically supports the piezoelectric element on the substrate and transmits the drive signal from the conductor pattern formed on the substrate to the piezoelectric element.

Claims 1 and 20 are not anticipated by Katsuma, Miyazawa or Vishnevsky '580. None of these references discloses an ultrasonic motor in which a piezoelectric element comes into contact with a movable member to drive the movable member as recited by independent claims 1 and 20.

For instance, Vishnevsky '580 discloses a piezoelectric motor having a stator 1 and a rotor 3. The stator 1 has a housing 7 and a piezoelectric oscillator 6 mounted to the housing 7. The piezoelectric oscillator 6 has a piezoelectric cell 9 with electrodes 13 and pushers 10, each pusher 10 having one end secured to one flat surface of the piezoelectric cell 9 so that a gap 14 is provided between the piezoelectric cell 9 and the pusher 10. The other end of each pusher 10 rests against the rotor 3.

Accordingly, Vishnevsky '580 fails to disclose a piezoelectric element provided on a substrate for undergoing oscillating movement in response to the drive signal so as to contact the movable member and thereby generate the drive force for driving the movable member. In Vishnevsky '580, elastic members, or pushers 10, are interposed between the piezoelectric cell 9 and the rotor to convert the vibratory movement of the piezoelectric cell 9 into rotary movement of the rotor 3.

Miyazawa discloses structure similar to that of Vishnevsky '580. For example, in the ultrasonic motor illustrated in Fig. 7 of Miyazawa, a piezoelectric element 3-1 is formed on a bottom surface of a stator 2-1. A rotor 1-1 has projections 1a-1 extending therefrom. The projections 1a-1 are disposed on a top surface of the stator 2-1. The piezoelectric element 3-1 is formed on the bottom surface of the stator 2-1 and never contacts the rotor 1-1. Thus, Miyazawa does not disclose a piezoelectric element provided on a substrate for undergoing oscillating movement in response to the drive signal so as to contact the movable member and thereby generate the drive force for driving the movable member as required by claims 1 and 20.

The ultrasonic motor of Katsuma is similar to that of Vishnevsky '580 and Miyazawa and the reference does not

disclose a piezoelectric element that comes into contact with a movable member as required by independent claims 1 and 20.

Nor do the references disclose or suggest a substrate having a conductor pattern for conveying a drive signal from a drive circuit, a piezoelectric vibrator provided on the substrate, and a support member for supporting the piezoelectric vibrator and transmitting the drive signal to the piezoelectric vibrator as required by claims 1 and 20. Nothing in the cited references would have suggested this combination of elements.

Anticipation under 35 U.S.C. §102 requires the identical disclosure by a single prior art reference of all elements of a rejected claim arranged exactly as recited in the claim. W.L. Gore & Associates v. Garlock, Inc., 220 USPQ 303, 313 (Fed. Cir. 1983), cert. denied, 469 U.S. 851 (1984) ("Anticipation requires the disclosure in a single prior art reference of each element of the claim under consideration"); Lindemann Maschinenfabrik GmbH v. American Hoist & Derrick Co., 221 USPQ 481, 485 (Fed. Cir. 1984) ("Anticipation requires the presence in a single prior art reference disclosure of each and every element of the claimed invention, arranged as in the claim") (emphasis added).

Since Vishnevsky '580, Miyazawa and Katsuma fail to identically disclose the subject matter recited in independent

claims 1 and 20, the anticipatory rejection of these claims should not be maintained.

Nor are independent claims 1 and 20 rendered obvious by the cited references. An obviousness rejection must demonstrate that all elements of a rejected claim are obvious, and must be based on a showing in the prior art of a suggestion or motivation to make a modification which renders an invention obvious within the meaning of 35 U.S.C §103. See, e.g., Symbol Technologies, Inc. v. Opticon, Inc., 935 F.2d 982, 989, 18 USPQ2d 1885 (Fed. Cir. 1991). The cited references fail to identically disclose the subject matter of claims 1 and 20, and fail to support the conclusion that the modifications needed to replicate the combinations recited in claims 1 and 20 would have been obvious. As described above, the ultrasonic motor of claims 1 and 20 has a piezoelectric element that comes into contact with a movable member and that is provided with a support member that transmits a drive signal to the piezoelectric element so that no conductive wires are needed. The inventive ultrasonic motor of these claims has an improved driving force, a reduced vibrational loss and smaller dimensions as compared with conventional ultrasonic motors. In the Fig. 1 embodiment, the piezoelectric vibrator 10 generates a rotational driving force in response to a received drive signal. A drive signal for

driving the piezoelectric element 10 is transmitted along leads 7 to a support member 11. The support member 11 supports, and is in electrical connection with, the piezoelectric vibrator 10 on the substrate 8. Thus, the support member is effective for both supporting the piezoelectric member 10 and for transmitting the drive signal from a conductor pattern formed on the substrate to the piezoelectric vibrator 10. The movable member 12 contacts the piezoelectric vibrator 10 and moves in response to the vibrational driving force. There is simply no teaching or motivation in the references for making any of the modifications necessary to achieve the claimed combinations. Thus, there is no support for a continued obviousness rejection of the claims.

Moreover, various dependent claims define separately patentable subject matter. In one aspect of the invention recited by claim 2, the support member has sufficient elasticity to elastically urge the piezoelectric vibrator against the movable member. Nothing similar is found in the cited references. As recited by claim 4, the support member comprises part of the substrate. Claim 7 recites that the support member is provided with at least part of the drive circuit. Claim 8 recites that the support member supports the piezoelectric vibrator at a point corresponding to a node of

vibration to reduce vibration loss. The subject matter of claims 4, 7 and 8 is not disclosed by the cited references.

In view of the foregoing amendments and discussion, the application is now believed to be in condition for allowance. Accordingly, entry of the present amendment together with favorable reconsideration and allowance of the claims are most respectfully requested.

Respectfully submitted,

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